CALIFORNIA
ENERGY
COMMISSION

RECOMMENDED BEST DESIGN PRACTICES FOR ALL NEW PUBLIC SCHOOLS

COMMISSION REPORT

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Gray Davis, *Governor*

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Executive Summary

This is a unique period in California education history. The state, already educating one out of every eight students in America, has enrollment rates four times higher than national averages. Hundreds of schools each year are needed to house the approximately 100,000 new students added to the public school system annually and to accommodate state-mandated class-size reductions. The current infrastructure is aging, and over 30 percent of existing facilities are in need of major renovation. California is responding to this infrastructure crisis with an unprecedented school construction program.

Building standards require schools to be safe, have comfortable and healthy environments, and be structurally sound and resource efficient. Building standards are the minimum thresholds that all building projects must meet.

At the same time, California schools are spending nearly $700 million per year on energy in a time of rising concern over energy supplies and tight school budgets. These figures illustrate an enormous opportunity for our state's school districts to build the next generation of school facilities that improve the learning environment while saving energy, resources, and money.

The new school infrastructure we are buying today will be with us for many years. How schools are built and designed now will determine both the quality of future education and the amount future generations will pay for the ongoing maintenance and operating costs of schools. The challenge is to use public money wisely ensuring that ongoing educational needs are cost effectively met so that future generations can better afford to maintain and operate the buildings constructed today. Substantial research has been completed, identifying the strengths and weaknesses of traditional school construction. New technologies and building practices have been identified to help achieve our goal of constructing a quality educational environment that is energy, water and resource efficient.

We know that over the life of a building taxpayers pay ten times the cost of school construction just in operating and maintenance and that school buildings influence student health and academic achievement. Some schools have been constructed that perform better than other schools as a quality learning environment as well as have lower ongoing energy and maintenance costs. This new generation of High Performance Schools maximizes energy efficiency, lighting and comfort design.

California has an historic opportunity to create schools that will serve the needs of future generations. Decision-makers need the vision, determination and knowledge to seize the opportunity available to ensure schools are constructed to meet these challenges.

In 2002, the Legislature directed the Energy Resources Conservation and Development Commission, in consultation with the State Department of Education, the Division of the State Architect and the Office of Public School Construction within the Department of General Services to recommend best design practices that include energy efficiency measures for all new public schools, including best design practices and measures that would be cost effective, and incorporate energy efficiency design and technology that would provide the greatest amount of energy efficiency savings within a seven-year cost recapture period.

This report builds on the excellent work that others have already done to establish best design practices for new school construction that are cost effective and can improve educational facilities in California. In particular, it recognizes the work done by the Collaborative for High Performance Schools (CHPS) in the development of the School Best Practices Manuals and the concept known as High Performance Schools.

This report does not recommend that schools be required to comply with higher building standard thresholds than any other building type would be required to meet. Rather, this report recommends that increased funding above standard allotment be provided for the voluntary building of High Performance Schools, to cover those integrated new building projects that have a cost recovery period of seven years, using either life cycle cost analysis or simple payback benchmarks of economic performance.

The additional funding for designs meeting the High Performance School criteria could be made available using procedures similar to those used in AB 16 (Hertzberg), Chapter 33, Statutes of 2002. Existing bond provisions established by AB16, required that in order for California Schools to be eligible for a grant adjustment (synonymous with the Energy Allowance Grant), the buildings proposed for the project shall exceed Title 24, Part 6 by an amount not less than 15 percent for new construction projects. The project must provide sufficient energy savings to return the cost of the initial investment in the project (i.e. Energy Allowance Grant) not to exceed seven years. The grant adjustment was not to exceed 5 percent of its state grant authorized by Sections 17072.10 and 17074.10 of the education code for the state's share of the costs associated with design and other plan components related to school facility energy efficiency. A similar grant adjustment made to qualifying High Performance School designs would help to encourage school districts to build better performing buildings.

Characteristics of a High Performance School

High performance schools are designed and built to exceed the minimum energy standards that apply to nonresidential construction in current Title 24 Building Energy Standards by at least ten percent. Fundamental building elements and systems are verified to be designed, installed, and calibrated to operate as intended, and provide for the ongoing accountability and optimization of building energy performance over time. They include the maximum use of daylighting to not only reduce peak electrical lighting loads but to also improve student productivity.

High performance schools provide a high level of thermal comfort. Adequate ventilation is supplied in order to provide good indoor air quality that will protect student and staff health, performance, and attendance. Noise from heating, ventilating and air conditioning (HVAC) systems, and noise from traffic and other outdoor sources are controlled so that acoustic levels do not interfere with student and teacher productivity.

School building sites are selected that protect students and staff from outdoor pollution and noise. All surface grades, drainage systems, and HVAC condensate are designed to prevent the accumulation of water under, in, or near buildings (especially portables).

Materials with low off-gasing of volatile organic compounds are used. The amount of construction and occupant waste entering the landfill is reduced, and the efficient reuse of materials and buildings is promoted. Water use is kept to a minimum.

High performance goals are integrated into district planning. Important concepts such as energy, water, and material efficiency are incorporated as teaching tools to illustrate a wide spectrum of scientific, mathematical, and social issues. HVAC systems, lighting equipment, and controls systems can be used to illustrate lessons on energy use and conservation, and daylighting systems can help students understand the daily and yearly movements of the sun.

Background

Legislative Direction: Senate Bill 284

SB 284 (Polanco), Chapter 498, Statutes of 2002, in recognition of the challenges facing California schools, added Section 17255 to the Education Code , and directed the California Energy Commission in consultation with the State Department of Education, the Division of the State Architect, and the Office of Public School Construction, to recommend best design practices for school construction that include energy efficiency measures for all new public schools.

Specifically, SB 284 states:

- The Energy Resources Conservation and Development Commission shall, in consultation with the State Department of Education and the Division of the State Architect and the Office of Public School Construction with the Department of General Services, recommend best design practices that include energy efficiency measures for all new public schools

- The practices and measures shall have as a goal incorporating energy efficiency design and technologies that would provide the greatest amount of energy efficiency savings within a cost recapture period of seven years

- The Commission may additionally recommend best design practices and measures that would be cost effective taking into consideration life cycle costs

- The recommendations shall be reported to the Governor and the Legislature by October 1, 2003

Best Design Practices

What are "Best Design Practices" for new school construction?

A substantial amount of research has already gone into answering this question. Numerous policies have been enacted over the years affecting the design and construction of school buildings regarding seismic stability, access, fire and safety. The Division of the State Architect has been directed to ensure that school buildings adhere to specific requirements for public schools and also comply with California's building codes and all health and safety requirements. In addition, there is new information being developed all the time leading to a better understanding of how buildings and technologies can improve the educational environment. Numerous agencies and private sector stakeholders have contributed resources looking into the challenges facing our schools.

In recent years, this collective research has led to the concept known as "High Performance Schools." High Performance Schools are made up of many integrated building blocks to address a range of concerns. High Performance Schools address health and comfort issues, are energy, water and resource efficient, safe and secure, adaptable, and easy to operate and maintain. How schools are designed affects the quality of the building, decades of ongoing operational expenses, and, most importantly, the health and productivity of generations of students and staff.

Benefits of a High Performance School

High performance schools improve the learning environment while saving energy, resources, and money. By incorporating the very best of today's design strategies and building technologies, high performance schools can simultaneously provide better learning environments for children, cost less to operate, and help protect the environment.

The designs do not have to be prohibitively expensive and time consuming. The key lies in understanding the lifetime value of high performance schools, hiring skilled designers, and effectively managing priorities during the design and construction process, all good business practices.

The quality of school facilities affects the district on many levels. The bottom line is high performance schools help educate students, resulting in six primary benefits:

- Higher test scores
- Increased average daily attendance
- Reduced operating costs
- Increased teacher satisfaction and retention
- Reduced liability exposure
- Reduced environmental impacts

These benefits are achievable, but only when districts establish high performance as a specific design goal from the onset and support this goal throughout the development process. A focus on student and teacher performance, coupled with a concern for the environment and a commitment to cost effectiveness, will help ensure that the effort is successful and that any school, no matter what its budget, achieves the highest performance level possible for its particular circumstances.

The Collaborative for High Performance Schools (CHPS) was formed in 1999 to address the need for better schools in California. CHPS includes a diverse range of state government agencies, utilities, and other school stakeholders with a unifying goal to improve the quality of education for California's children. CHPS developed a series of "Best Practices" manuals for school planning, design and a pass/fail scoring system to determine if a school meets the High Performance School criteria. In early 2002, CHPS incorporated as a nonprofit organization, further solidifying its commitment to environmentally sound design that enhances the educational environment for all schoolchildren.

CHPS participants include:

- California Air Resources Board
- California Department of Education
- California Department of Health Services
- California Division of the State Architect
- California Energy Commission
- California Integrated Waste Management Board
- California Office for Public School Construction
- Coalition for Adequate School Housing
- Los Angeles Department of Water and Power
- Natural Resources Defense Council
- Pacific Gas and Electric Company
- Sacramento Municipal Utility District
- San Diego Gas and Electric
- Southern California Edison
- Southern California Gas Company
- A number of architects and engineers in private practice

This report builds on the "Best Design Practices for School Construction" developed by this collaborative. These practices are tailored to California and incorporate a multi-disciplinary approach to school construction with emphasis on designs that help improve the educational environment, reduce operating costs and support environmental public policy goals in California. From an energy perspective, the "Best Practices" developed by CHPS proposes that school architects and engineers go beyond minimum energy efficiency codes. A high performance school must exceed minimum performance criteria in many areas including energy efficiency.

Aren’t California schools already required to comply with strict energy codes?

Yes, all new schools in California are subject to meeting California’s minimum energy efficiency requirements contained in Title 24, Part 6 for nonresidential buildings. California energy codes are subject to public review and must be, by law, cost effective. They are updated every three years to accommodate changes in technology, energy rates and improved building science. Assumptions used to determine cost effectiveness are conservative and applicable to all nonresidential building types. Often, new, more stringent energy requirements than the existing code have already been proven cost- effective and wait only for the regulatory calendar to go into effect. For example, schools constructed today are subject to the 2001 energy code. Yet, the 2005 energy codes are under development and are scheduled to go into effect in 2005. The proposed 2005 code is much more stringent than 2001 and has already undergone public review and has been determined to be cost effective. Building code requirements lag behind what is cost effective for many reasons. Well designed buildings today often are designed and built to be considerably better than required by the minimum energy code.

Good architects and engineers recognize that the greatest value to the taxpayer usually means going beyond the minimum. For example, the minimum efficiency requirement for a rooftop air conditioner has a Seasonal Energy Efficiency Ratio (SEER) of 9.7 today, yet SEER 14 units are commercially available and cost effective on most school building situations. Another example, current energy codes allow a classroom lighting power budget (that is the amount of power permitted to illuminate a classroom per square foot of space) of 1.4 watts per square foot, yet many designers are creating appropriate classroom lighting systems at 1.0 watt per square foot. This is due largely to recent advances in both the quality and efficiency of lighting technologies.

School buildings have even better opportunities than private sector buildings for cost effectively exceeding the energy code minimum because of the lower cost of capital. School construction bonds are tax exempt making the cost of capital nearly two to five percent lower than for private sector borrowers. Some school districts are in higher electricity and natural gas cost areas, and therefore, energy efficiency projects in these regions are more cost effective.

CHPS Demonstration Schools

The CHPS High Performance School best design practices have already made a significant positive impact on California school new construction. Various members of CHPS have sponsored school new construction projects designed to meet the CHPS Best Practices Criteria. Listed on the following page are High Performance Schools that are being sponsored by CHPS participants and a list of school districts that have passed resolutions that require using the High Performance School Criteria.

Demonstration Project Case Study: Georgina Blach Intermediate School

In the fall of 2002, students enrolled at the Georgina Blach Intermediate School in Los Altos, California, walked into a newly remodeled, high performance school facility. The remodeled school demonstrates how energy and resource efficient technologies can be successfully incorporated. This project is one of the first schools in California to be designed and built to criteria developed by the Collaborative for High Performance Schools.

Through the extensive use of daylighting to augment electrical lighting, thoughtful lighting design, a cool roof, improvements in thermal comfort from insulation, heating, ventilation, and air conditioning improvements, and proper maintenance procedures to keep the buildings operating as they were designed to do, the school now enjoys a more comfortable and high quality learning environment. The renovation project implemented energy efficiency measures that are expected to yield electricity savings of 34 percent beyond the minimum code requirements, along with associated utility bill savings.

The project also completed a commissioning process to ensure that specific building systems perform according to the design intent and the school district's operational needs.

A detailed case study about the demonstration project is available online at
http://www.energydesignresources.com/
For more information about high performance school design and CHPS, please visit the CHPS website at http://chps.net/

Figure 1

CHPS SCHOOLS

☆ **CHPS Demonstration Schools:**

- Cahuenga New Elementary School, Los Angeles
- Cesar E. Chavez Education Center, Oakland
- Georgina Blach Intermediate School, Los Altos
- Newport Coast Elementary School, Newport Beach
- Rustic School, Manteca
- Southeast Learning Center, Huntington Park
- Truckee Middle School, Truckee
- El Segundo High School, El Segundo

◇ **School Districts Using CHPS Guidelines:**

- Coast Community College
- Dry Creek Joint Elementary School District
- Harmony Union Elementary
- Los Angeles Unified School District
- San Rafael City Schools
- Santa Ana Unified School District

Cost Effectiveness of the Recommended Best Design Practices

What are the recent school funding measures?

California voters have approved two major bond measures in the last few years. Proposition 1A was passed in November of 1999 for the amount of $9.2 billion with $6.7 billion designated for Kindergarten through 12th grade (K-12) public school modernization and construction. Proposition 47 was passed in November of 2002 for the amount of $13.5 billion with $11.4 billion designated for K-12 school construction and modernization. Voters will potentially approve another statewide bond measure, scheduled for March of 2004, for approximately $12.3 billion with approximately $10 billion designated for K-12 school construction and modernization. These bonds, coupled with local school construction bonds will mean over $60 billion in public funds going into construction and modernization of our K-12 schools in only one decade. California's school construction capital outlay projects collectively represent the single largest public works investment in the nation. A significant amount of these funds is exclusively for the construction of new K-12 schools.

What are the best economic benchmarks to evaluate?

SB 284 requires that recommendations for best design practices include energy efficiency measures for all new public schools. The legislation asked the Commission to evaluate best practices that are cost effective from a cost recapture period, or payback perspective, as well as a life cycle cost perspective.

> *"The practices and measures shall have as a goal incorporating energy efficiency design and technologies that would provide the greatest amount of energy efficiency savings within a cost recapture period of seven years."*

The bill also asks for recommendations regarding life cycle costs in making this determination. It asks the Commission to:

> *"... recommend best design practices and measures that would be cost effective taking into consideration life cycle costs."*

The following figure provides an overview and comparison of the simple payback methodology and the life cycle cost methodology. It indicates that, using either of these methodologies, there are a wide variety of common technologies that are shown to be cost effective and exceed minimum energy standards.

Figure 2
Simple Payback versus Life Cycle

Simple Payback is the period of time required for the cumulative cash inflows from a project to equal the initial investment.

Life cycle Costing is a method of analyzing a project in which all costs arising from owning, operating, maintaining, and ultimately disposing of a project are considered.

	Simple Payback	Life cycle Costing
Pros	• Simple to use • Provides a ballpark measure of project risk • Provides a measure of project liquidity	• Well suited to analyzing building design alternatives requiring a specific level of performance • Useful to compare projects with different lives • Can account for operation, maintenance, and repair costs
Cons	• The payback period is arbitrary • Ignores all costs and benefits after the payback period has passed • Ignores the time-value of money	• More complicated and time consuming to run the calculations • More complex to understand and explain than payback

Incremental Costs[1] and Benefits of Best Practices for New School Construction

School Type	Hard Costs	Soft Cost	Total Initial Costs	Average Energy Use[2]	10% Energy Savings	Simple Payback (Years)	Life Cycle Cost (Per sq ft)
	Cost per square foot						
K-6	$0.58	$0.35	$0.93	$1.31	-$0.13	7.1	-$0.63
7-8	$0.58	$0.39	$0.97	$1.61	-$0.16	6.0	-$0.95
9-12	$0.58	$0.42	$1.00	$1.75	-$0.18	5.7	-$1.08

[1] Total estimated incremental costs of measures designed to exceed minimum energy code by 10%. (Includes – cool roof, efficient lighting, photosensors, occupancy controls, economizers and operable windows.)
[2] Average annual energy cost by school type based on Bright Schools Program energy audits conducted between 2001-2003.

SB 284's requirement that the Best Practices measures have a cost recovery of seven years or less is similar to a requirement contained in AB 16 (Hertzberg), Chapter 33, Statutes of 2002, which authorized Proposition 47, the November 2002 school bond. AB 16 authorized an energy grant for new schools that exceed minimum energy standards by 15 percent or more. AB 16 restricted the eligible grant to not more than five percent of the state construction grant with energy savings to return the initial investment in the project in not more than seven years. Using the AB 16 guidelines, the Commission worked with the Office of Public School Construction to develop a method to determine the amount of energy grant funding that could be provided to any new school applicant. The methodology used standard approved energy code compliance software called Energy Pro. This software is widely used to document compliance with the Energy Code requirements and is written so that the major operating assumptions are locked, and therefore, consistent outputs on energy design can be evaluated. This compliance software's output became the basis for providing incentives to improve energy performance of schools. The Commission worked with the Office of Public School Construction and the Proposition 47 Implementation Committee to develop the procedure and the regulations for allocation of the energy allowance funds. Additional funds were provided to schools achieving exemplary energy performance in the design phase. The energy allowance program is described below.

The energy allowance program provides funding to help offset the first cost of energy efficient equipment needed to improve energy efficiency. The assumption behind the energy allowance effort was simple. By providing this additional funding to offset the first costs, school districts and their architects would be motivated to make the best economic decisions, long-term school operational costs would be lowered, and the State would benefit by needing fewer power plants.

This same idea could be extended beyond energy to other design parameters to further promote best practices for school construction established by the CHPS. AB 736, (Hancock), introduced in the 2003 session of the legislature (currently pending in Senate Appropriations) proposed that a two percent increase in the state grant be provided to school districts meeting the High Performance School Criteria established by CHPS. Currently, the State provides $5,200 to $7,200 per pupil, depending on grade level, of grant eligibility for new construction projects.

Other non-monetary incentives could be offered such as expedited funding and permitting. The use of incentives appears to significantly increase interest in improving the energy efficiency of schools and is a strong motivator for school districts and school designers to focus more effort into making new schools perform better.

How Proposition 47 Energy Allowance was Determined

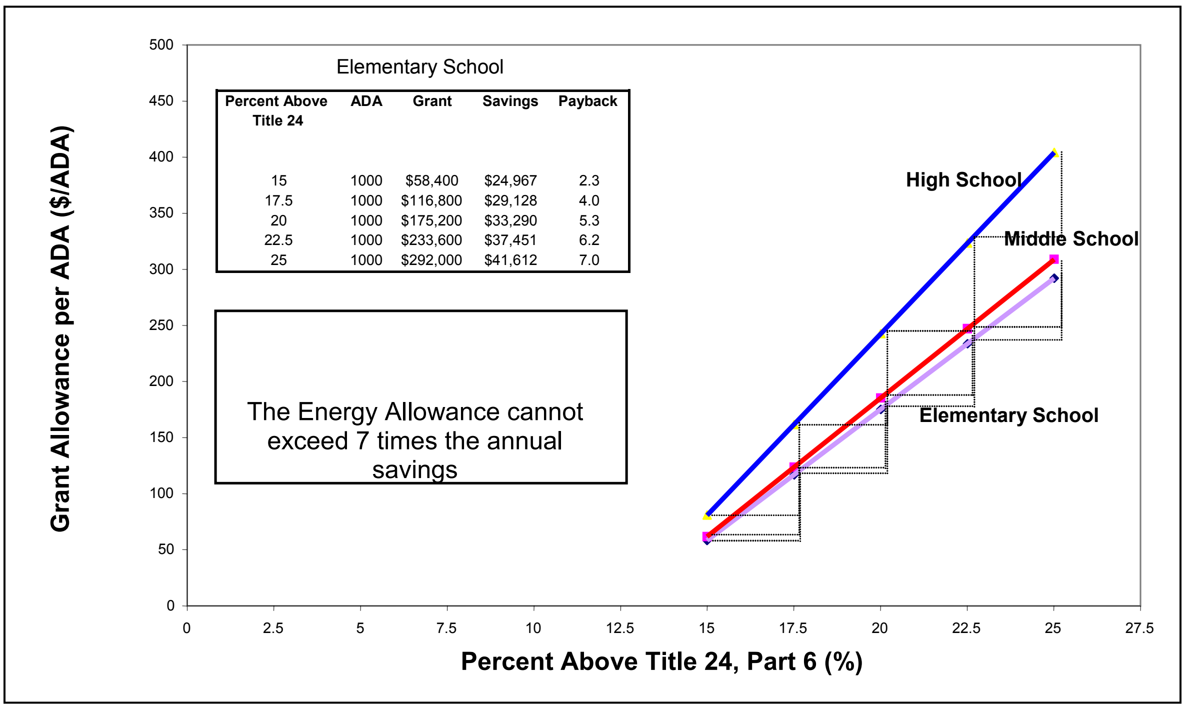
AB 16 required that in order for California Schools to be eligible for a grant adjustment (synonymous with the Energy Allowance Grant), the buildings proposed for the project shall exceed Title 24, Part 6 by an amount not less than 15 percent for new construction projects. The project must provide sufficient energy savings to return the cost of the initial investment in the project (i.e. Energy Allowance Grant) not to exceed seven years. The grant adjustment was not to exceed 5 percent of its state grant authorized by Sections 17072.10 and 17074.10 of the Education Code for the state's share of the costs associated with design and other plan components related to school facility energy efficiency.

Assumptions

California has very diverse weather represented by 16 climate zones, energy balances differing with geographical location and 3 major utility service territories. Energy variables including energy usage, energy balance, electricity cost and natural gas cost were averaged for representative schools throughout California and coupled with the type of school (elementary, middle, and high) and the number of students.

Figure 3 illustrates the grant adjustment per average daily attendance (ADA) allowed for State bond funding for new schools exceeding the Title 24, Part 6 Energy Code. There is one sliding scale linear plot for each type of school (Elementary, Middle and High).

Figure 3
Proposition 47 Energy Allowance versus Percent above Title 24, Part 6



Percent Above Title 24	ADA	Grant	Savings	Payback
15	1000	$58,400	$24,967	2.3
17.5	1000	$116,800	$29,128	4.0
20	1000	$175,200	$33,290	5.3
22.5	1000	$233,600	$37,451	6.2
25	1000	$292,000	$41,612	7.0

Integrated Life Cycle Cost Analysis

Maximum flexibility to the architects and school districts are provided when school building projects are designed as a whole system, rather than a collection of stand-alone components. Occasionally, stand-alone components that make a lot of sense in a project are discarded only because they were analyzed alone. Costs and benefits should be bundled, treating a project as one system rather than separate components.

Many trade-offs are made during the design phase of a building project so that the project meets both the building program goals and stays within the budget. It is recommended that design professionals be given the responsibility to put together a school building project that meets the program requirements, which includes the delivery of a High Performance School that can be financially justified as an integrated design.

What are the Economic Benefits of Establishing Best Practices?

The incremental cost of building schools to the best practices standard is made up for over the building's life as a result of many direct and indirect cost savings. From an energy perspective, the reduction in utility bills from use of efficient technology and design principles is well documented. There are added cost savings to school districts building a high performance school.

The following benefits also accrue to school districts following the best practices. Although difficult to quantity, they nevertheless will provide cost savings to schools:
- Improved health and productivity of students and teachers
- Extended building life through the use of quality materials
- Designs that allow optimum use of existing real estate avoid expensive land procurement, transportation and other costs
- Designs that have minimal negative impacts on the environment

High performance design is cost effective. Energy-efficient schools cost less to operate, which means that more money can be used for books, computers, teacher salaries, and other items essential to the educational goals of schools. Energy-efficient schools also reduce air pollution by reducing emissions to the environment from power plants.

High performance schools have multiple benefits. For example, they can:
- Bring more money to the school by reducing absenteeism -- increasing average daily attendance
- Keep more money in the school by significantly reducing utility bills
- Take advantage of available incentive programs
- Reduce risk and liability associated with indoor air quality and other environmental problems
- Help retain teachers and staff

When the avoided costs of workers' compensation claims and litigation are also considered, high performance schools become an even wiser business choice for school districts

In designing a high performance school it is critical to effectively mange priorities during the design and construction process. School districts can specify that a design incorporate energy efficiency design and technology that would provide the greatest amount of energy efficiency savings within a seven-year cost recapture period. A school district must identify and prioritize goals, and hire designers with the appropriate skill sets. Without the luxury of expansive timelines and budgets, every school design becomes a balanced system of trade-offs. Understanding the value of high performance design will be important as choices arise.

In addition to requirements to comply with a list of mandatory measures, like lighting controls, there are two methods for complying with Energy Standards. One method of compliance involves meeting minimum performance standards for a prescriptive list of measures. The other compliance method involves energy modeling of a school project using a computer model to compare a baseline Title 24 Energy Standard building to a proposed building that uses less energy. The computer program models the building envelope, lighting and mechanical (heating and air conditioning) systems and provides a performance number, per square foot, for both the baseline Energy Standard and the proposed energy efficient building. The difference between the standard and proposed models determines the percent above Title 24. The computer modeling compliance method is required to establish that a school building project exceeds Title 24 by ten percent. If additional costs for high performance schools do arise they would mainly be related to commissioning and the possible need for energy modeling for those projects that would have used the prescriptive method of compliance.

Many high performance measures can be incorporated into a school design without increasing first costs, but additional investments can increase the health and efficiency of the school even further.

The considerable costs of poor school indoor environmental quality are borne by students, staff, parents, and the local community. In the school populations, the costs include poor health, reduced learning effectiveness, and increased frustration when indoor environmental quality problems become unmanageable. These costs are difficult to quantify. More easily counted are the strained budgets and staff resources expended by districts for facility repairs due to insufficient maintenance, community relations damage control, litigation, and workers' compensation claims. In addressing such problems, schools must use resources that would otherwise be available for educational and other programs. Poor school indoor environmental quality can cause both short-term (reversible) and long-term (chronic) effects in students and staff. The economic costs of these long-term, possibly lifelong, diseases are substantial, the costs in terms of quality of life are more profound, and certainly difficult to measure.

Flexibility of CHPS Best Practices Criteria

The CHPS Criteria explicitly define a high performance school. The CHPS Criteria span a wide variety of areas, from site planning and energy use, to material specifications and district resolutions. There are prerequisites in the criteria that are typically design issues required by state law. However, the design must move beyond the prerequisites to ensure that the CHPS school is healthy, operates efficiently, increases student productivity, and reduces environmental impact.

The criteria are most useful as a goal-setting and planning tool. Districts can use it to simply and clearly communicate their design goals. At the same time, the criteria's flexibility allows designers to deliver a CHPS school while managing the regional, district, and site-specific constraints of the school design.

What are the Recommended Best Design Practices for all New Public Schools?

Energy Efficiency

California's Energy Standards, contained in Part 6 of Title 24, are typically updated every three years. They are justified on life cycle cost, and the recommendations are usually well known and available up to two years in advance of their effective date. This report recommends that the Legislature set as a goal that new schools be designed to exceed the minimum standards that apply to nonresidential construction in Title 24 by at least ten percent. This recommendation will insure schools are built today to meet tomorrow's standards and avoid higher operational costs by reducing energy use. Schools have many cost effective opportunities to exceed minimum energy requirements. The energy calculations should be modeled in compliance with all the rules outlined in the Alternative Compliance Manual. It provides guidance for establishing building base case development and analysis.

Often, practical and straightforward measures can reduce energy use by over 30 percent from the 2001 edition of Title 24, Part 6.

Commissioning

Commissioning of a building verifies that fundamental building elements and systems are designed, installed, and calibrated to operate as intended, and provide for the ongoing accountability and optimization of building energy performance over time.

Characteristics of A High Performance School

"High performance school" refers to the physical facility — the school building and its grounds. Because schools are complicated structures, high performance design covers a broad and diverse range of disciplines and choices. It is a design philosophy focused on choices that improve the learning environment and save resources.

Schools are unique structures, housing one-fifth of the population every school day - almost 6 million children and more than 200,000 teachers and support staff. Occupant density is approximately four times as great as a typical office building, and schools include many "special use" areas all within the same facility. Creating a high performance school is not difficult, but it requires an integrated, "whole building," team approach to the design process. Key systems and technologies must be considered together from the beginning of the design process and optimized based on their combined impact on the comfort and productivity of students and teachers.

High performance schools are:

- Healthy, with good indoor air quality
- Thermally, visually, and acoustically comfortable
- Cost effective
- Energy efficient
- Material efficient
- Water efficient
- Easy to maintain and operate
- Environmentally responsive
- A teaching tool
- Safe and secure
- Architecturally pleasing
- A community resource

This report recommends that all new schools receiving funds from the State file a project commissioning plan. High performance schools can only be achieved with some level of commissioning. No matter how carefully a school is designed, if the building materials, equipment, and systems weren't installed properly or aren't operating as intended, the health, productivity, and other benefits of high performance design will not be achieved. Commissioning is a quality assurance program that is intended to show that the building is constructed and performs as designed. It is a powerful tool to indicate if the designers and contractors have done what they were hired to do. Studies show that many building systems will not operate as expected unless they are commissioned. One study of 60 newly constructed, nonresidential buildings revealed that more than half had controls problems, 40 percent had malfunctioning HVAC equipment, and one-third had sensors that did not operate properly. In many of the buildings, equipment called for in the plans and specifications was actually missing. One-fourth of the buildings had energy management control systems, with economizers or variable-speed drives that did not run properly.

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the contract documents, the design intent, and the district's operational needs. The commissioning process integrates the traditionally separate functions of design peer review, equipment startup, control system calibration, testing, adjusting and balancing, equipment documentation, and facility staff training, as well as adds the activities of documented functional testing and verification. Commissioning is occasionally confused with testing, adjusting, and balancing. Testing, adjusting, and balancing measures building air and water flows, but commissioning encompasses a much broader scope of work. Commissioning typically involves four distinct "phases" in which specific tasks are performed by the various team members throughout the process. The four phases are pre-design, design, construction, and warranty. During the construction phase, commissioning involves functional testing to determine how well mechanical and electrical systems meet the operational goals established during the design process. Although commissioning can begin at the construction phase, districts receive the most cost effective benefits when the process begins during the pre-design phase when the project team is assembled.

Indoor Environmental Quality

Best practices for school construction go far beyond just energy efficiency. A high performance school building needs to be healthy and productive. Best practices for school construction therefore must include measures to enhance indoor environmental quality. This report recommends achieving best practices in the following areas.

Daylighting

School designs should maximize the use of daylighting to not only reduce peak electrical lighting loads but to also improve student productivity. According to the CHPS best practices manual, student and staff productivity can be improved through quality daylighting designs that minimize glare and diffuse sunlight into the classroom. The designs should provide a connection between indoor spaces and the outdoor environment by providing views to the outside of the building. This report recommends that at least 75 percent of the classrooms in the school should have a minimum Daylight Factor of 2 percent. The Daylight Factor is the ratio of exterior to interior illumination.

Indoor Air Quality

School designs should insure adequate ventilation, providing good indoor air quality that will protect student and staff health, performance, and attendance. The designs should meet the performance requirements of Cal/OSHA Minimum Ventilation Standard of 15 cubic feet per minute per student. This includes designing building ventilation systems to ensure the continuous delivery of outside air to a level no less than the governing design standard, and the ventilation should occur at all times that the rooms are occupied, and not be readily circumvented (i.e., blocked registers or windows). To ensure adequate fresh air, building outdoor air intakes should be located away from loading areas, building exhaust fans, cooling towers, and other sources of contamination.

Water Drainage

Design all surface grades and drainage systems, including the drainage of condensate water from heating, ventilating, and air-conditioning systems, to prevent the accumulation of water under, in, or near buildings. Irrigation systems should not spray on buildings.

Low Volatile Organic Compound (VOC) Materials

Indoor air quality can benefit from using materials with low off-gassing of volatile organic compounds. A recent California Air Resources Board report cited the prevalence of formaldehyde in many classrooms in California, particularly in relocatable units. Minimizing emissions from materials, controlling sources of pollution during construction, commissioning, and regular maintenance are all critically important to protecting indoor air quality.

Noise

Noise is proving to be a major problem for some children especially in their early years. The hard of hearing and English as a second language students are disadvantaged in classrooms that have high levels of background noise. Best practices call for the design of heating, ventilating, and air-conditioning systems to provide acoustic levels that do not interfere with student and teacher productivity. A school classroom should have maximum unoccupied background noise levels of 45 decibels with a 0.6-second maximum reverberation time.

Thermal Comfort

Design for a high level of thermal comfort. This means that high performance schools need to have adequate heating and cooling and ventilation capacity to provide teacher and student comfort. Architects also need to provide teachers the ability to control temperature and ventilation to support optimum health, productivity, and comfort conditions. However, this does not mean over-sizing of heating, ventilating, and air conditioning systems. Equipment should be appropriately sized; otherwise there is substantial energy inefficiency in oversized equipment.

Environmental, Resource Efficiency and Public Policy Objectives

School construction projects are one of the largest public works expenditures of society. As such, they should include provisions to carry out basic public policy objectives. Best practices for school construction includes provisions to ensure public policy objectives are achieved.

Water Efficiency

School design should ensure that water use is kept to a minimum, not only saving costs for water but also helping to conserve a valuable resource. Schools should avoid excess water use for landscaping and ornamentation by designing a landscape and ornamental water use budget that conforms to the local Water Efficient Landscape Ordinance. If no local ordinance is applicable, then designers should use the landscape and ornamental budget outlined by the California Department of Water Resources. Maximizing the water efficiency within buildings will also reduce the burden on municipal water supply and wastewater systems.

Waste Material Reduction

School projects should reduce the amount of construction and occupant waste entering the landfill and promote the efficient reuse of materials and buildings. The school should meet local ordinance requirements for recycling space, and provide an easily accessible area serving the entire school that is dedicated to the separation, collection, and storage of materials for recycling including, at a minimum, paper (white ledger, mixed, and cardboard), glass, plastics, and metals.

School construction projects should meet local ordinance requirements concerning construction and demolition materials at construction sites, if applicable, and develop and implement a waste management plan, quantifying material diversion by weight to recycle, compost, and/or salvage at least 50 percent (by weight) of construction, demolition, and land clearing waste.

Best practices includes specifying building products that incorporate recycled-content material, thus reducing the impacts resulting from extraction of new material, sparing additional burdens on landfills and spurring the market for recycled goods. Consideration should also be given to reducing the use and depletion of finite raw and long-cycle renewable materials by replacing them with rapidly renewable materials and encourage environmentally responsible forest management by specifying that wood products be certified by independent third-party groups such as the Forest Stewardship Council.

School designs would specify rapidly renewable building materials for at least five percent of total building materials. Rapidly renewable resources are those materials that substantially replenish themselves faster than traditional extraction demand; do not result in significant biodiversity loss, increased erosion, or air quality impacts; and are sustainably managed.

Site Selection Considerations

Projects should comply with all siting and environmental impact study requirements of the School Facilities Planning Division as defined in Title 5, Division 1, Chapter 13 of the California

Code of Regulations. Sites should be chosen that protect students and staff from outdoor pollution, including noise, and minimally impact the environment. Channeling development of new schools to centrally located areas with existing infrastructure will help to protect greenfields, minimize transportation requirements, and preserve habitat and natural resources.

District Resolutions

High performance goals should be integrated into district planning. Districts should pass board-level resolutions that integrate high performance standards in the preparation and revision of district educational specifications and building programs. All new facilities should be required to be high performance schools.

Portable Classrooms

Portable or "relocatable" classrooms have been a feature of U.S. schools for years. Relocatables range in quality, so care should be taken to ensure that the investment in relocatables and student health are not compromised on low-quality designs, or the lack of commissioning and maintenance.

Specifying construction and furnishing materials in relocatable classrooms to have good indoor air quality is important. Pressed-wood products (often with high concentrations of formaldehyde) are used more in the factory-built relocatable units than in buildings constructed on-site. As a result, levels of airborne chemicals may be higher in new relocatable classrooms, especially if ventilation is reduced.

The Facility as a Teaching Tool

By incorporating important concepts such as energy, water, and material efficiency, schools can become tools to illustrate a wide spectrum of scientific, mathematical, and social issues. Heating, ventilation, and air conditioning systems, lighting equipment, and controls systems should be used to illustrate lessons on energy use and conservation, and daylighting systems should help students understand the daily and yearly movements of the sun. School building materials and water management features can be used to introduce concepts of ecology and to add practical examples to environmental and resource conservation topics.

Conclusion

The new school infrastructure we are buying today will be with us for many, many years. These recommended Best Design Practices will cost effectively create safe, healthy and pleasant environments for California's students and teachers. How schools are built and designed today will determine both the quality of future education and the amount future generations will pay for the ongoing maintenance and operating costs of schools. These recommended practices will meet the challenge to use public money wisely to ensure that the on-going educational needs are cost effectively met so that future generations can better afford to maintain and operate the buildings we construct today.

These Best Design Practices are a wise investment for taxpayers because operating and maintenance costs are ten times the first cost of school construction. California has a historic opportunity to create schools that will serve the needs of future generations. All that is needed is the vision, determination and knowledge to take the opportunity available to us to ensure schools are constructed to meet these challenges.

This report recommends increasing funding above standard allotment for the building of public schools to school districts that voluntarily build High Performance Schools, to cover those integrated new building projects that have a cost recovery period of seven years, using either life cycle cost analysis or simple payback benchmarks of economic performance.

The additional funding for designs meeting the High Performance School criteria could be made available using procedures similar to those used in AB 16 (Hertzberg), Chapter 33, Statutes of 2002. Existing bond provisions established by AB16, required that in order for California Schools to be eligible for a grant adjustment (synonymous with the Energy Allowance Grant), the buildings proposed for the project shall exceed Title 24, Part 6 by an amount not less than 15 percent for new construction projects. The project must provide sufficient energy savings to return the cost of the initial investment in the project (i.e. Energy Allowance Grant) not to exceed seven years. The grant adjustment was not to exceed 5 percent of its state grant authorized by Sections 17072.10 and 17074.10 of the education code for the state's share of the costs associated with design and other plan components related to school facility energy efficiency. A similar grant adjustment made to qualifying High Performance School designs would help to encourage school districts to build better performing buildings.